Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 5 (2011) 1898–1903

Energy Procedia

IACEED2010

Sectoral Fluctuations and Macro-economic Fluctuation: Based on Input-Output Matrix

ZHAO Juan*

School of Economics, Huazhong University of Science and Technology, Wuhan 430074, PRC

Abstract

This paper establishes a bivariate VAR model in sectoral level. Using a weighted matrix from an input-output table, we model an economic system which reflects the interdependence of all the sectors. During empirical analysis, we estimate the VAR model for 17 Chinese sectors in the sample period from 1985 to 2008. Generalized impulse response function is used to analyze the dynamic effects of real output growth and fixed asset investment growth. The results show that Chinese economic system has diversity and no any industry has absolute dominance in the system. To some extent, the economic growth in China is pulled by investment on short term. We also find that when the real output of Manufacture of Machinery and Equipment is given one negative shock, the volatility of the economic system mainly comes from the manufacturing industries. If the authorities take policy to stimulate the production, it's possible to aggravate the fluctuation in the adjustment process of economic system. The economy will be short-term overheating.

Selection and peer-review under responsibility of RIUDS

Keywords: Input-Output; VAR; Generalized Impulse Response Function

1. Introduction

In 2008, the international economic environment changed largely. Chinese exportation reduced sharply. At the end of 2009, how to speed up the change in the mode of economic development was emphasized in the Central Economic Work Conference. In economic growth from extensive to intensive process of change, sectoral restructuring plays an important role. Then, how do industry fluctuations effect macro-economy? How to understand the macroeconomic impact from a specific sectoral adjustment?

* Corresponding author. Tel.: +086-132-0718-8871
E-mail address: zhaojuanhust@yahoo.com.cn

doi:10.1016/j.egypro.2011.03.326

1.1. Literature Review

There are a lot of literature on economic fluctuations and changes of sectoral structure in Chinese. We can divide them into two phases. The first phase of the research focused on the relationship between macro-economic volatility and sectoral volatility. Xu Jingjun and Liu Heng (2005) pointed out that in the process of sectoralization in China, the three periodic fluctuations had their own traits with different kinds of influence on the national economy[1]. Sun Guangsheng (2006) came to the conclusion that economic fluctuation was the comprehensive result of the fluctuation of various industries[2].The second phase further analyzed the causal relationship between them. Some literature concluded that macroeconomic fluctuations caused the changes of sectoral structure. Ning Xiaoqing and Chen Bofu (2008) found that fluctuations in the economic cycle was an important reason for changes of sectoral structure[3]. Other literature supported the point that the sectoral fluctuations induced economic fluctuations. Li Yun-e (2008) empirical study found that macro-economic fluctuation and sectoral structure were closely related. Different industries made different contributions to macro-economic fluctuation. Macro-economic fluctuation was not the fundamental reason for the adjustment of sectoral structure[4].

These literature mainly chosed the three industries as objects of study, directly using time series data of the three industries. But the inter-sectoral interactions were ignored. In one economic system, intermediate products used in an sectoral are the products of other sectors, and the production scale of an industry are also constrained by the production scale of other industries. Therefore, if we ignore the impacts of interaction among industries through using intermediate goods, some important information would probably been missed.

1.2. Structure

In this paper we construct a VAR model of a single sector, then use the input-output table to construct a weighted matrix to link all sectors each other. This approach was proposed by Pesaran et al (2004) , called a global vector autoregressive model (Gloabal VAR, GVAR) [5]. We analyze empirically different impacts of different sectoral fluctuations on the other sectors. The paper is structured as follows. In Section 2 we provide a sectoral VAR model. The data are described in Section 3. Section 4 documents generalized impulse response function analysis and Section 5 concludes.

2. Sectoral VAR model

Ma Jiantang (1988) pointed out that investment was subdivided into specific sector investment and it was assets for a particular sector[6]. Therefore, the cyclical changes of investment focus or investment compositions certainly led to a corresponding change in industry structure. He also stressed that investment was an important intermedia in the mechanism that economic cycle fluctuations affected sectoral structure in China.Therefore, we select the bivariate VAR model to analyze the dynamic relationship among economic variables. Growth rate of sectoral real output and growth rate of sectoral fixed asset investment are endogenous variables.

As sample data are limited, we use a bivariate VAR model with lagged 2 order,

$$\mathbf{X_{it}} = \mathbf{a_i} + \mathbf{A_{i1}}\mathbf{X_{it-1}} + \mathbf{A_{i2}}\mathbf{X_{it-2}} + \mathbf{C_{i0}}\mathbf{X^*_{it}} + \mathbf{C_{i1}}\mathbf{X^*_{it-1}} + \mathbf{H_i}d_i + \boldsymbol{\varepsilon_{it}} \quad (1)$$

$$i = 1,2,3\cdots,N; t = 1,2,3\cdots,T$$

Which assumes that random innovations $\boldsymbol{\varepsilon_{it}}$ are serially uncorrelated with a zero mean and a non-singular covariance matrix $\sum_{\mathbf{ii}} = Cov(\varepsilon_{ilt}, \varepsilon_{ist})$.

$\mathbf{X_{it}} = [y_{it}, FI_{it}]'$, $\mathbf{y_{it}}$ is growth rate of i th sectoral real output and FI_{it} is growth rate of i th sectoral fixed asset investment. $\mathbf{X^*_{it}} = [y^*_{it}, FI^*_{it}]' = [\sum_{j=1}^{N} \omega_{ij} y_{jt}, \sum_{j=1}^{N} \omega_{ij} FI_{jt}]', \omega_{ii} = 0$. The weights ω_{ij} correspond to the share of products j th used as input material in i th sector. We construct the industry cross sectional average to capture factor demand linkages between industries in the economy.

d_t is a common weak exogenous variable for each sector, which is defined as the broad money supply growth rate to reflect the monetary policy on industry fluctuations. $\mathbf{X^*_{it}}$ is all sectors of the economic system weighted average of the original variables. We regard $\mathbf{X^*_{it}}$ as a proxy variable for the macroeconomic impact on sectors and it is weakly exogenous.

Define $\mathbf{X_t}$ as a matrix of all endogenous variables. Weighting matrix $\mathbf{W_i}$ which contains a unit matrix, zero and specific weight. For example, $\mathbf{W_1}, \mathbf{W_N}$ can be written as

$$\mathbf{W_1} = \begin{pmatrix} 1 & 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & 0 & \cdots & 0 & 0 \\ \omega_{11} & 0 & \omega_{12} & 0 & \cdots & \omega_{1N} & 0 \\ 0 & \omega_{11} & 0 & \omega_{12} & \cdots & 0 & \omega_{1N} \end{pmatrix}, \mathbf{W_N} = \begin{pmatrix} 0 & 0 & 0 & 0 & \cdots & 1 & 0 \\ 0 & 0 & 0 & 0 & \cdots & 0 & 1 \\ \omega_{N1} & 0 & \omega_{N2} & 0 & \cdots & \omega_{NN} & 0 \\ 0 & \omega_{N1} & 0 & \omega_{N2} & \cdots & 0 & \omega_{NN} \end{pmatrix}$$

As $\mathbf{W_i X_t} = [\mathbf{X_{it}}, \mathbf{X^*_{it}}]'$, the model (1) can be rewritten as

$$\mathbf{G_{i0} X_t} = \mathbf{a_i} + \mathbf{G_{i1} X_{t-1}} + \mathbf{G_{i2} X_{t-2}} + \mathbf{H_i} d_t + \boldsymbol{\varepsilon_{it}} \quad (2)$$

$$\mathbf{G_{i0}} = (\mathbf{I_i}, -\mathbf{C_{i0}})\mathbf{W_i}, \mathbf{G_{i1}} = (\mathbf{A_{i1}}, \mathbf{C_{i1}})\mathbf{W_i}, \mathbf{G_{i2}} = (\mathbf{O_{2\times 2(i-1)}}, \mathbf{A_{i2}}, \mathbf{O_{2\times(N-2i)}}), i = 1, 2, ..., N$$

The above model is for a single sector. If we put all sectors together, the economic system model is

$$\mathbf{G_0 X_t} = \mathbf{a} + \mathbf{G_1 X_{t-1}} + \mathbf{G_2 X_{t-2}} + \mathbf{H} d_t + \boldsymbol{\varepsilon_t} \quad (3)$$

$$\mathbf{a} = [\mathbf{a_1}, \mathbf{a_2}, \cdots, \mathbf{a_N}]', \mathbf{G_0} = [\mathbf{G_{10}}, \mathbf{G_{20}}, \cdots, \mathbf{G_{N0}}]', \mathbf{G_1} = [\mathbf{G_{11}}, \mathbf{G_{21}}, \cdots, \mathbf{G_{N1}}]', \mathbf{G_2} = [\mathbf{G_{12}}, \mathbf{G_{22}}, \cdots, \mathbf{G_{N2}}]',$$

$$\mathrm{H} = [\mathrm{H_1}, \mathrm{H_2}, \cdots, \mathrm{H_N}]'$$

As parameter matrix $\mathbf{G_0}$ is reversible, model (3) can be rewritten as

$$\mathbf{X_t} = \mathbf{G_0^{-1} a} + \mathbf{G_0^{-1} G_1 X_{t-1}} + \mathbf{G_0^{-1} G_2 X_{t-2}} + \mathbf{G_0^{-1} H d_t} + \mathbf{G_0^{-1}} \boldsymbol{\varepsilon_t} \quad (4)$$

3. Data

3.1. Data description

Before 1979, there was the highly centralized management system in China. The mechanism of cycle fluctuations affecting the sectoral structure's change was restricted. Since the reform and opening up, Chinese economy experienced from the planned economy over to market economy. In order to reduce the estimate error in terms of structure change, we choose the sample period from 1985 to 2008. This data comes mainly from National Bureau of Statistics website.

In this paper, we use the input-output value table to construct the weighted matrix. Input-Output Table is transformed into a weighting matrix by column standardization, such that each column sums to one. Wang Yueping and Geyue Jing (2007) compared input-output tables of 1997 and 2002 and found that production technology and price had led the consumption and substitution of inputs changed, however the sort of influence coefficients was not influnced for little magnitude of change[7]. Therefore, we use input-

output table of 2002 to compute weighting matrix and the whole economy is divided into 17 sectors according to it[1].

3.2. Data test

Usually if without constraints, the number of parameters estimated in model (3) is more than the number of samples, and the model couldn't be estimated. However, due to the weights of the model is given, there is no need to simultaneously estimate them with other parameters. As long as three conditions hold: model (3) is dynamically stable; $\omega_{ij} \geq 0$ and small enough; cross-dependence of the idiosyncratic shocks is sufficiently small, we could estimate model (1) sector by sector, and estimate the parameters and covariance matrix in model (3).

3.2.1. Stationary test

We use DF-GLS method to test all variables' stationary. This method uses GLS estimate after detrending. The test statistic is t statistic of the parameter. The test results show that for each sector, at 5% significance level, all series are stationary. Therefore, the growth rates of real output and fixed asset investment are I(0) process. $\mathbf{X}_{\mathbf{it}}^{*}, \mathbf{d}_{\mathbf{t}}$ in model(1) are weakly exogenous variables, so the parameters of single sectoral model estimated by the least squares method are consistent estimation.

3.2.2. Weak cross-sectional correlation

One important assumption in GVAR model is that there should be weak cross-sectional correlation among individual shocks, so that $n \to \infty, Cov(\mathbf{X}_{\mathbf{t}}^{*}, \mathbf{u}_{\mathbf{t}}) \to 0$. This assumption ensures $\mathbf{X}_{\mathbf{t}}^{*}$ weak exogeneity.

Because it is a proxy variable for the macroeconomic impact of sector i, $\mathbf{X}_{\mathbf{t}}^{*}$ should be able to reduce the cross-sectional correlation in the system. We compare the average pairwise correlation coefficients of residuals from model (1) and from model (1) with $\mathbf{C}_{\mathbf{i0}} = \mathbf{0}$ and $\mathbf{C}_{\mathbf{i1}} = \mathbf{0}$. The results show that regardless of the impact of common elements or sectoral linkages, almost all average pairwise correlation coefficients of residuals decrease as $\mathbf{X}_{\mathbf{t}}^{*}$ is included in model.

4. Generalized Impulse Response Analysis

Orthogonalized Impulse Responses Function (OIRF) is a traditional method in VAR analysis. OIR method requires a series of shocks are orthogonal, and the results of the orthogonal impulse response depends on the system variables and sector order. However, in an economic system, the industries linkage each other, the natural order does not exist. Pesaran, MH and Shin, Y. (1998) proposed the nonlinear model of generalized impulse response functions (Generalized Impulse Response Function, GIRF) [8]. GIRF method takes into account the impact of individual errors. So GIRF could provide useful information about the transmission of shock from a sector to other sectors. We first analyze the response of aggregate output to the shock of one positive standard deviation from single sectoral real output and

---

[1] They are: Agriculture, Forestry, Animal Husbandry & Fishery; Mining; Manufacture of Foods, Beverage & Tobacco; Manufacture of Textile, Wearing Apparel & Leather Products; Other Manufacture; Production and Supply of Electric Power, Heat Power and Water; Coking, Gas and Processing of Petroleum; Chemical Industry; Manufacture of Nonmetallic Mineral Products; Manufacture and Processing of Metals and Metal Products; Manufacture of Machinery and Equipment; Construction; Transport, Storage, Post and Information Transmission; Wholesale and Retail Trades, Hotels and Catering Services; Real Estate, Leasing and Business Services; Financial Intermediation; Other Services.

fixed asset investment. The response of aggregate output is constructed with the appropriate weights that reflect industry sizes. Then we analyze a specific industry.

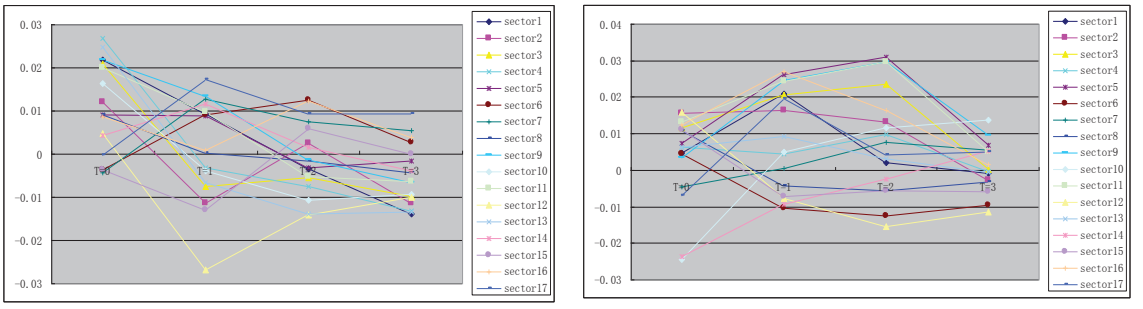

Fig. 1. (a) Response of aggregate output to $\mathbf{y}_i$; (b) Response of aggregate output to $\mathbf{FI}_i$

The figure 1 compares the response of aggregate output to one positive standard deviation shock of a sectoral real output with its response to one positive standard deviation shock of fixed asset investment. We find the following characteristics:

- Firstly, from current to 3 years later, both the impact of a single industry output and the impact of fixed asset investment on aggregate output are less than 0.03%. This shows that Chinese economic system has diversity and no any industry has absolute dominance in the system. So Chinese economic system has an anti-risk ability.
- Secondly, response of aggregate output to one positive standard deviation impact of every sectoral real output almost all reverses (except for Financial Intermediation), while its responses to one positive standard deviation impact of fixed asset investment of five sectors are positive continuously. These sectors are Manufacture of Foods, Beverage & Tobacco; Other Manufacture; Manufacture of Nonmetallic Mineral Products; Manufacture of Machinery and Equipment; Financial Intermediation.
- Thirdly, on average, currently response of the aggregate output to one positive standard deviation shock of every sectoral real output is larger than impact of fixed asset investment. Three years later, on the contrary the later is larger. This shows that fixed asset investment has greater and more durable impact on aggregate output. To some extent, it reflects that economic growth in China is pulled by investment on short term.

The following figure 2 shows the response of the economic systems to shock of output and shock from fixed asset investment from Manufacture of Machinery and Equipment sector. We find that on average the former's response rate is less than the latter's; the response speed of the former is faster than the latter. In sectoral level, the manufacturing industries' responses are greater than Primary industry and Tertiary industry (excluding Real Estate, Leasing and Business Services). Different manufacturing industries' responses are different. For example, the responses of Mining and Coking, Gas and Processing of Petroleum are lagging and the responses of four industries' output are more sensitive (They are Manufacture of Textile, Wearing Apparel & Leather Products, Other Manufacture, Manufacture and Processing of Metals and Metal Products and Manufacture of Machinery and Equipment.).

This result suggests that, given an external negative shock on manufacturing output, if the authorities take policy to stimulate the production, it is possibly aggravate fluctuation in the adjustment process of economic system. The economy will be short-term overheating.

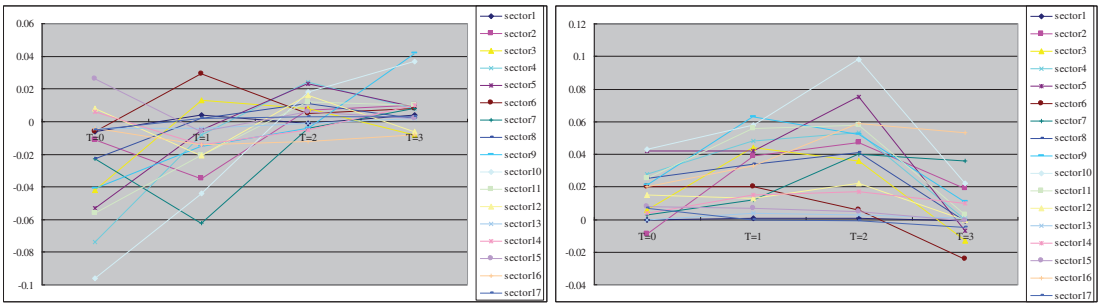

Fig. 2. (a) One negative S.D. innovations on y_{11}; (b) One positive S.D. innovations on FI_{11}

5. Conclusion

This paper constructs a VAR model with sectoral linkage. Through the generalized impulse response analysis, we draw the following conclusions:

- Firstly, Chinese economic system has diversity and no any industry has absolute dominance in the system. So economic system in China has an anti-risk ability. Fixed asset investment has greater and more durable impact on aggregate output. To some extent, it reflects that economic growth in China is pulled by investment on short term.
- Secondly, when the real output of Manufacture of Machinery and Equipment is given one negative S.D. shock, the volatility of the economic system mainly comes from the manufacturing industries.
- Thirdly, given an external negative shock on manufacturing output, if the authorities take policy to stimulate the production, it is possible to aggravate the fluctuation in the adjustment process of economic system. The economy will be short-term overheating.

There are still some issues to be resolved in next research. For example, the generalized impulse response includes feedback among industries, so we can decompose the impulse responses in the future.

References

[1] Xu Jingjun, Liu Heng. The Traits of Sectoral Structure of the Periodic Fluctuation of China s Economy. *Journal of Yunnan University for Nationalities(Social Sciences)* 2005;3:31-7(in Chinese).

[2] Sun Guangsheng. Economic and Sectoral Fluctuations(1986-2003): A Preliminary Study of Correlation, Features and Driving Forces. *Social Sciences in China* 2006;3:62-3(in Chinese).

[3] Ning Xiaoqing, Chen Baifu. Empirical Analysis on the Relationship between Economic Cycle Fluctuation and Sectoral Structure Change in China. *Journal of Central University of Finance & Economics* 2008;11:61-6(in Chinese).

[4] Li Yun-e. An empirical analysis of maro economic fluctuation and industry construction change. *Journal of Shandong University(Philosophy and Social Sciences)* 2008;3:120–6(in Chinese).

[5] Pesaran, M. H., Shuermann, T., Weiner, S.M. Modelling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model. *Journal of Business & Economic Statistics* 2004;22:129-162.

[6] Ma Jiantang. Cycle fluctuations and structural changes. *Economic Research Journal* 1988;6:65-3(in Chinese).

[7] Wang Yueping, Ge Yuejing. Analysis of Input-output Related characteristics of the sectoral structure. *Management World* 2007;2:61-8(in Chinese).

[8] Pesaran, M.H., Shin, Y. Generalized Impulse Response Analysis in Linear Multivariate Models, *Economics Letters* 1998;58:17-29.